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MALARIA AND THE ENGINEER

:: A TREATISE FOR TECHNICAL STUDENTS ::

TROPICAL DISEASES BUREAU
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PREPARED BY THE
COMMITTEE ON SANITARY ENGINEERING
OF THE
NATIONAL MALARIA COMMITTEE

PUBLISHED BY
ST. LOUIS SOUTHWESTERN RAILWAY LINES



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MALARIA AND THE ENGINEER

TOPICS

1. Why Engineering Students Should Be Informed Regarding Malaria.
2. What Is Necessary to Produce Malaria.
3. Some Economics Of Malaria Control.
4. The Ways in which Engineering Projects Increase the Prevalence of Malaria.
5. How the Engineer can Avoid Creating Malaria.
6. What the Engineer Should Know of the Control of Malarial Infected Humans.
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INTRODUCTION.

Assistant Surgeon General, Dr. H. R. Carter, of the United States Public Health Service, states that over 50 per cent of the malaria in many parts of this country is "man-made." Most of this "man-made" malaria is the result of work over which engineers have control. To the uninformed engineer, this statement means but little, but when studied in the light of economic losses totalling millions of dollars each year and of the untold misery occasioned by sickness and death due to the ravages of "chills and fever," it seems the part of wisdom to have our young engineers fully informed concerning this disease.

Through the courtesy of Mr. Edwin Gould, Chairman of the Board of Directors, St. Louis Southwestern Railway Lines, these notes have been published for general distribution in schools of engineering in the United States. The Committee on Engineering of the National Malaria Committee expresses its gratitude to Mr. Gould for his part in the publication of these notes and at the same time compliments his good judgment in being one of the pioneers in this country in the development of a malaria control program on a large railway system if for no other reason than its being a sound business investment.

This committee has deemed it advisable to make these notes as clear and non-technical as possible and feels assured that, in presenting these major facts in malaria control to the graduating classes of our schools of applied science, the effect will be far reaching in a few years. A lecturer talking on this subject can use his judgment as to what portions of this paper should be used as a basis for a lecture to a senior class each year. It is suggested that the "malaria primer," (Malaria, Lessons on its Cause and Prevention, supplement No. 18, Public Health Reports) be used to supplement the lecture and each member of the class be presented with a copy of it.

- J. A. LE PRINCE, Chairman,
Senior Sanitary Engineer, U. S. P. H. S.,
Memphis, Tennessee.
- L. L. HIDINGER,
President, Morgan Engineering Company,
Memphis, Tennessee.
- S. H. McCRORY, Chief, Division of Agricultural
Engineering, U. S. Department of Agriculture,
Washington, D. C.
- H. W. VAN HOVENBERG, Sanitary Engineer,
St. Louis Southwestern Railway Lines,
Texarkana, Texas.
- Committee on Sanitary Engineering.

MALARIA AND THE ENGINEER

A TREATISE FOR TECHNICAL STUDENTS.

(1) *Why Engineering Students Should Be Informed Regarding Malaria:*

Sanitary science teaches that malaria, or "chills and fever," is carried from a person suffering with this disease to a well person by certain mosquitoes, and in no other way. The presence of these mosquitoes in any locality is a function of the topographic and climatic conditions. Engineering activities that change the natural topography produce effects that are measured by the toll in human lives and untold economic losses due to the creating of "man-made" mosquito breeding areas. The young engineer owes it to his profession, if not for his own reputation, to be informed against his being unwittingly the means of introducing malaria to new regions or of increasing the prevalence of this disease in those parts of our country that already have such a serious problem to solve. The young engineer's greatest asset, his good health, is at stake, whenever he labors in a malarial zone. Whether he be an electrical, chemical, civil, or sanitary engineer, he will more than likely be involved at some time in the construction of railways, highways, water power developments, drainage projects, or building of industrial enterprises, both in this country and in the Latin American countries south of us. He can avoid the creating of new malarial areas only by being self informed and by practicing what he knows.

(2) *What Is Necessary To Produce Malaria:*

A person suffering with malaria has in his blood the parasites of this disease. These parasites are very numerous and live at the expense of the red blood cells that are essential to life. Malaria parasites live only in the body of man and in the body of the Anopheles, or malaria carrying, mosquitoes. In countries where Anopheles are absent, there is no transmission of malaria. The female mosquito obtains malaria parasites while biting chronic malaria sufferers, and at a later period, while she is biting other persons, malaria parasites pass into the blood of the person bitten. Obviously, in any locality where malaria prevails, there must be: first, human beings suffering with malaria; secondly, favorable conditions for the production of malaria carrying mosquitoes; and thirdly, access of the yet uninfected and the infected mosquitoes to human beings.

In order that the engineer may not be responsible for creating conditions favorable for the production of malaria mosquitoes, he should be informed on mosquito life and development. (For clear and concise description, see supplement No. 18, United States Public Health Service reports.) Mosquitoes lay eggs which develop into larvae, or wiggle-tails. The larvae change to pupae from which mosquitoes emerge. The eggs will not hatch unless placed in water. Male mosquitoes die in the autumn and the fertilized females hibernate during cold weather and lay their eggs in the spring or early summer. In warm weather these eggs develop into mature insects in about 10 to 12 days or less. The eggs are laid on water surfaces, generally where there is sufficient protection for the young larvae, as in old borrow pits, improperly made or stagnant ditches, ponds, swamps, edges of lakes, collections of floating debris, et cetera.

There are four kinds of *Anopheles*, or malaria mosquitoes, in the United States that are of sanitary importance. The following characteristics apply to all of them. The larvae, or wiggle-tails, of the malaria mosquito (*Anopheles*) live, feed and generally remain on the surface of the water in a horizontal position, while those of other mosquitoes feed on the bottom and come to the surface to breathe, hanging at an inclined angle to the water surface. The adult mosquito avoids direct sunlight and rests in wind sheltered and sun shaded places, as the shaded side of tree trunks in wooded areas, in hollows of stumps, etc., and in settlements in sleeping rooms of residences, in stables, under houses, in culverts, et cetera.

When at rest, the malaria mosquito takes a different posture from that of other mosquitoes. They hold their proboscis, head and body in a straight line and at an angle of 30 to 90 degrees with the surface on which they rest. Other mosquitoes rest in a hunch-back position, their bodies being more or less parallel to the surface on which they rest. We might say the malaria mosquito appears to stand on its head, and at rest looks like a brad or small headless nail driven into the wall. They have spotted or mottled wings, whereas practically all other species have clear wings. They seldom attack in direct sunlight but bite mostly after dusk. When being produced in quantity under favorable conditions, as in rice fields, suitable lake margins, etc., they travel as far as a mile or a mile and a quarter from the production area to habitations and stables. When production conditions are less favorable, the usual flight range appears to be half a mile or less. The flight distance refers to *Anopheles quadrimaculatus*, probably the most important of all American species as a malaria carrier, and holds true for our southern states.

That portion of the United States over which the *Anopheles* mosquito may be found in sanitary importance, reaches from the state of New York along the Atlantic Sea Board to the Gulf of Mexico, and westward to the state of Missouri and south through all the states bordering on the Gulf of Mexico. In the past few years, there has been a sudden development of malaria in the fertile valleys along the western coast of the United States and in the recently reclaimed arid regions of the Southwest. It is estimated that in the southern states alone there were 3,000,000 people suffering with malaria during the year 1921, with a death toll of 15,000 persons. The economic loss to the United States is estimated by Dr. L. O. Howard, Chief of Bureau of Entomology, U. S. Department of Agriculture at \$100,000,000 annually. The enormous annual losses are occasioned by what is an actually preventable disease, and yet one that has often been given new life in the *Anopheles* area by the uninformed engineer creating new "man-made" mosquito producing areas.

(3) *Some Economics of Malaria Control:*

(a) When malaria prevails so as to be of sanitary importance, the health status and efficiency of engineering survey parties may be seriously lowered, and the rate of progress reduced. Parties may have to be reinforced or disbanded and costs are increased.

(b). Construction or maintenance work may be slowed up as the working force becomes less physically fit, and the economic advantage of a season favorable for construction operations may be lost. Labor turnover and labor shortage become more serious and expensive. With fixed overhead charges, decreased progress means a material increase in costs.

(c). Time contracts may be delayed or forfeited and valuable time lost. Cost of construction is increased, due to reduced output of physical energy of a large part of the working force. As the malaria season reaches its peak, a shortage of labor is of common occurrence when a high percentage of laborers on the job become infected. They are physically unable to do a full day's work, even though they do receive a full day's pay.

(d). On railway systems in malaria infested territory, we expect and do have a seasonal shortage of efficient mechanics in the shops, a high labor turnover for track gangs, and an expensive recruiting service, hence a high annual loss. On some railroads, one-half of the patients in the hospital are malaria cases. The yearly economic

loss on one single branch of a southern railroad was \$60,000, which did not include loss due to reduction of freight hauled.

(e). Manufacturing industries, lumber mills and lumber camps have seasonal shortages of labor, expensive labor turnover, decreased output, and sometimes largely decreased profits during the malaria season. In the proceedings of the third annual conference of the Malaria Field Workers of the United States in 1921, A. W. Fuchs, Sanitary Engineer of the United States Public Health Service, reported that in an investigation of a total of 31,000 cases of malaria in the United States, the average loss per person infected was \$44.00 for the season. This included the lost wages, cost of medicine, and medical aid.

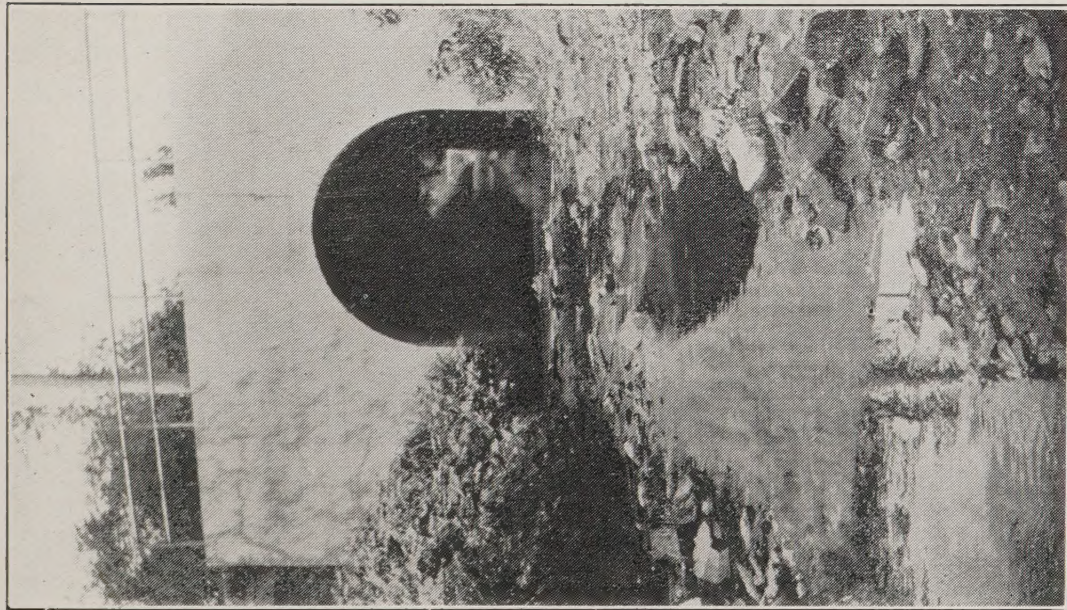
In the Mississippi delta, malaria is very prevalent. The physicians of Mississippi report from 100,000 to 150,000 cases of malaria each year. Other states on the coastal plain and in the Mississippi delta have similar malaria rates. Without question, the prevalence of malaria has been the cause of delay in the development of the richest portion of the Mississippi delta, much of which is yet but sparsely settled.

Dr. H. R. Carter, Assistant Surgeon General, United States Public Health Service, at the Wilmington, N. C. Conference of Sanitary Engineers (see page 11, Public Health Bulletin No. 104) stated: "A striking illustration of the disastrous effect of malaria is afforded by the history of the lower peninsula of Virginia. Constituting, as it did, the earliest English settlement in America, and containing, as it does, excellent farming land, it is significant that this region is still practically uninhabited. On many parts of the peninsula there is hardly a family to 3 square miles. Though school histories do not mention the fact, it is on record that Jamestown was abandoned 'because of epidemics.'

"For the South as a whole it is safe to say that typhoid fever, dysentery, pellagra, and tuberculosis, all together, are not as important as malaria."

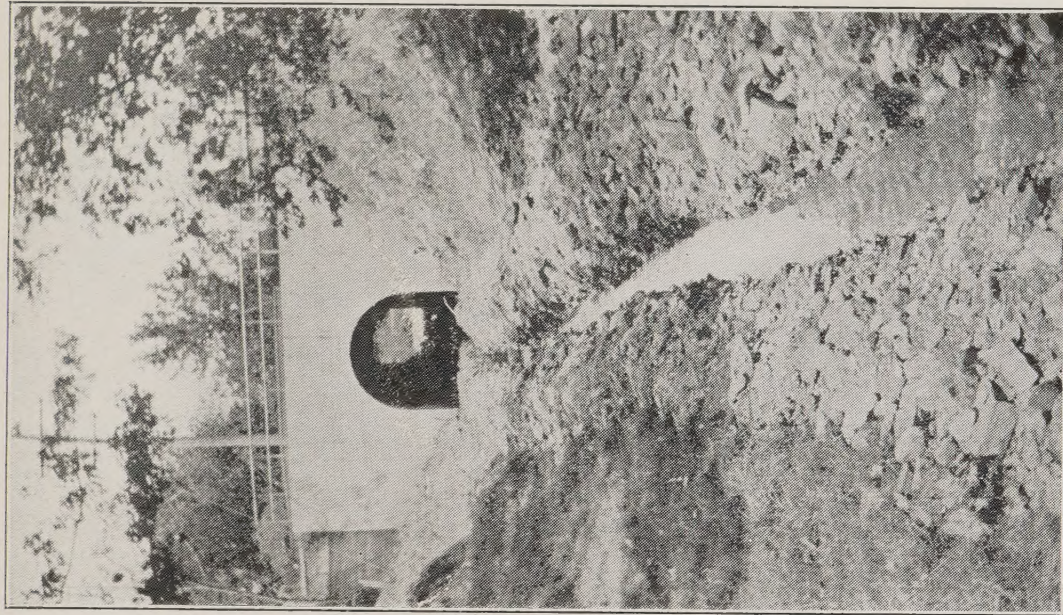
The loss in the irrigation district of Shasta County, California, in 1918, averaged \$31.70 per family, and in a rural area of 25 square miles in Mitchell County, Georgia, during the same year, the loss amounted to more than \$12.00 per acre under cultivation.

Previous to malaria control operations at Roanoke Rapids, Vir-



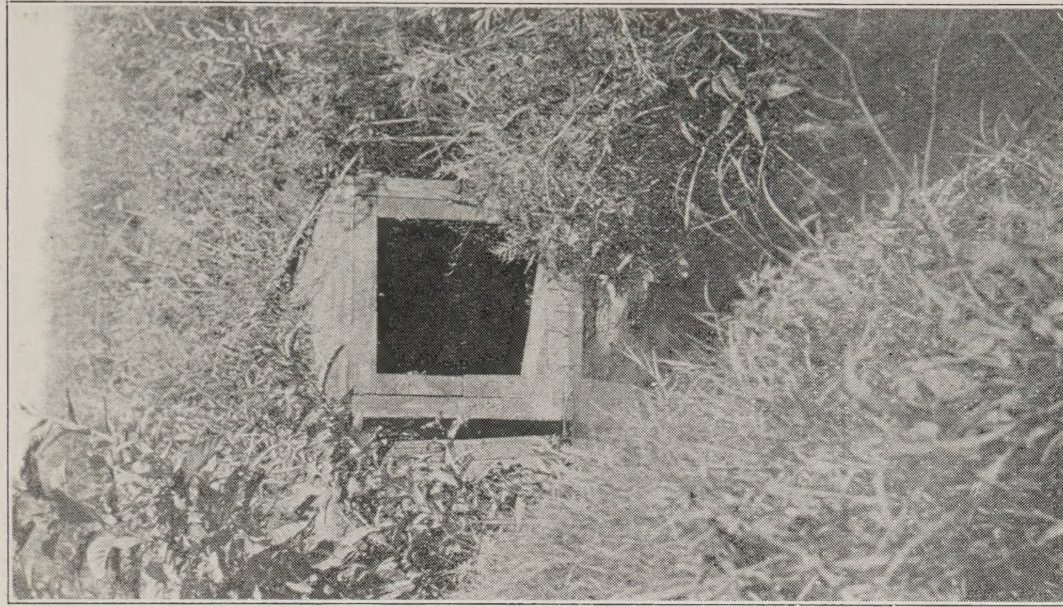
A Typical City Stream Before Ditching and Clearing of Vegetation.

+ Appo



The Same Stream After Ditching and Clearing to Prevent Mosquito Production.

+ Appo



A Road Culvert Placed at too high an Elevation to Drain Completely — a "Man-Made" Mosquito producing area.

+ Appo



Unscreened Dwellings Adjacent to Swamps Cause Much Unnecessary Malaria.



A Typical "Man-Made" Railroad Borrow Pit that Produces Many Mosquitoes Because It Cannot be Drained.



Mosquito Production can be Materially Reduced by Maintaining a Small Section Ditch in the Bottom of a Large Drainage Ditch where the Soil Formation Allows.

ginia, the managers of the cotton mills estimated their employees' efficiency at 40 to 60 per cent during the malaria season of four months.

Before malaria control was started at Perry, Florida, the wholesale cost of quinine and chill tonic alone bought by the town averaged over six dollars per capita. The large lumber corporation there, referring to the result of the campaign, wrote: "In our opinion, the efforts and expenses of the malaria campaign are fully justified in the increased labor efficiency thus obtained, and we anticipate keeping up our anti-malaria program as long as we remain here. We would strongly advise every lumber mill in the country to do the same thing."

The anti-malaria campaign at Keltys, Texas, resulted in the San Augustine Lumber Company shipping 20 per cent more lumber in 1917 than ever before, and that was a year of extreme shortage of labor. The increased revenue to the railroad amounted to \$30,000 that season.

The large saw mill and box factory at Kress, Virginia, states that minor drainage operations near their plant in 1915 and 1916 were worth \$35,000 per year to the company. The malaria campaign there saved them 20 times what it cost.

In a hundred communities undertaking malaria control operations in the United States during the last two years, the average cost in the first year has been about 80c per person, or a little over one dollar per acre under control. The average cost of maintaining the anti-malaria protection after the first year was 20c per capita or 35c per acre. The amount of malaria reduction has been from 75 to 95 per cent.

(4) *Ways in Which Engineering Projects*

Increase the Prevalence of Malaria:

Undrained It is not uncommon for persons engaged in highway and railroad construction to leave one or a series of undrained borrow pits along a roadway. Such places become intermittent or permanent producing areas of malaria mosquitoes. All such borrow pits should, whenever possible, be made self-draining at time of low water. Many miles of these borrow pits and wide bottom ditches that become a series of stagnant pools are unfortunately being made on construction work under the supervision of engineers. These pits will be the cause of much suffering, of a heavy financial loss to the community, and are at times the cause of death.

High Culverts Culvert pipes along railroads and highways are frequently placed too high. This causes pools to form and often renders impossible subsequent drainage of standing water upstream from the culvert.

Clay Pits Pits from which clay is obtained for manufacture of brick and tile are seldom properly drained and are frequently located within Anopheles flight range of towns or villages. Such pits as well as quarries ultimately became the permanent sources of malaria mosquitoes.

Faulty Drainage Construction Drainage measures are often referred to as health measures, but fail in that respect frequently because more attention is devoted to RAPID removal of storm water than to the removal of ALL water after the storm has gone by. It is the latter water only that is a menace to health. We frequently see pools adjoining embankments, which could have been drained at little cost before the embankments were made, but which will be expensive to drain later.

When wide ditches are necessary, it is advantageous to have a small ditch within the bed of the wide bottom ditch when the grade and soil will permit. For malaria control purposes, it is advisable either to eliminate sluggish or standing water or else reduce its surface dimensions to a minimum. Arrangement should be made for proper periodical maintenance of drainage ditching systems. Where possible, ditches should have clean cut sloping edges, narrow bottoms and straight courses. Where ditches remain wet, care should be taken to reduce the number of branch or spur ditches to a minimum. Branch ditches should join main ditches at an acute angle or curve in order to lessen deposition of solids in time of storm. Where ditching is done without regard to mosquito control, it often becomes a prolific source of malaria mosquitoes.

Irrigation Projects In some of our irrigation systems, water is allowed to seep through the embankments into undrained borrow pits. In the Rio Grande Valley, malaria is thus rapidly developing as the irrigation projects are extended.

Faulty
Street
Ditches

Southern communities in the malaria belt have found it advantageous to employ civil engineers as city managers, and it is important that such officials, as well as city and county engineers, realize the relation of malaria control to the welfare and development of the community they represent. Street ditches that are apt to retain storm water during wet periods must be kept at proper grade and should be given more attention and inspection than those that remain dry. As a rule, this is not done, and as a result, the taxpayer in addition to paying for road maintenance, may have his earning power decreased and a doctor and druggist bill to pay to cure the disease caused by the neglected road ditch.

Suburban
Roadside
Ditches

The suburbs of some of our southern towns are highly malarial, because engineers in the past were not taught the essentials of malaria control and its importance. Quite recently in one of our large seaboard cities, 40 per cent of the families of a rich suburb were infected with malaria. The major source of the trouble was wet roadside ditches, while the municipal engineering forces were employed in another part of the town cleaning vegetation from the banks of a dry ditch that never was a sanitary nuisance. Such ridiculous practice is not uncommon. Water courses that become a series of pot holes in the summer usually do more harm and send more persons to bed sick than do open sewers.

Untrained
Water
Courses

The coming generation will be aware that proper Anopheles drainage is just as important and necessary as street paving. The time will soon be here when the public will not tolerate water courses through settlements in the malaria belt. When the streams cannot be carried underground, their bottom section should be lined with concrete. In many instances, it is advisable to make this concrete line section one that will be the center floor section of the concrete floor of the future storm water culvert. This narrow central section will keep the water in motion, will be cleared out by each storm flow and will prevent Anopheles propagation.

Catch Basins

Street storm water catch basins are frequently a prolific source of pestiferous mosquitoes, and when possible, should be so modified as to be slowly self-draining during dry periods.

Street Extension The extension of streets in suburbs on flat and water tight lands, where the street ditches will hold water is a serious menace to health. It should be the business of the city engineer to see that proper ordinances are passed to enforce the installation of proper concrete curb and gutter as rapidly as old streets are extended, or new ones opened.

Concrete Lined Ditches There is a great opportunity for the engineer to give wise advice regarding the municipal activities that will eliminate disease bearing and pestiferous mosquitoes. The permanent results obtainable by the economical concrete lining of insanitary ditches are such that the entire public can see and appreciate. It is a means of making the engineer's advice more frequently sought and considered in regard to other municipal projects. Today we yet have cities with malaria mosquitoes being produced in the earth street ditches on all four sides of a single block, and the economic loss caused by malaria is far greater than the cost of permanent concrete curb and street gutters.

(5) *How the Engineer Can Avoid Creating Malaria:*

Drainage
Drainage Maintenance
Fish Control
Application of Larvacides

Drainage In thickly settled communities, we should determine the cost of drainage operations for Anopheles control and for its maintenance before work is started. What a community can afford to pay for Anopheles control drainage operations is covered by reprint No. 595, United States Public Health Service.

Drainage for malaria control consists of the removal of water that remains after rain storms have passed. It is not essential that the remaining storm water be removed rapidly, but it is advisable to keep the water in permanently flowing ditches in fairly rapid motion. For that reason, it is advantageous to have ditches with a narrow bottom cross section. Permanent pools, swampy areas, etc., should be drained when necessary and practical to do so, or so reduced in area as to lessen subsequent treatment of remaining waters to a minimum.



Method of Spraying Larvacide or Oil on Pools so as to Prevent Mosquito Production.



A Typical Railroad Camp on Wheels. Note that the Windows and Doors are Screened to keep Mosquitoes out.

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Land Cleared of Trees ready for Ditching with Dynamite.



A typical ditch made with dynamite through the same character of land as shown above.

The malaria mosquito can develop in water having a depth of one-quarter of an inch. There is no advantage in the drainage of bodies of water that do not produce the class of mosquitoes we desire to eliminate. In soils in which the ditches remain wet, there is a tendency to install too many branch or spur ditches. This increases the cost of maintenance considerably. Therefore, it is advisable in draining swampy areas for malaria control purposes to install main ditches and laterals and then give the ground an opportunity to dry out before locating the smaller ditches and spurs. It frequently takes less ditching for mosquito control than it would for agricultural purposes.

Maintenance So far as mosquito production is concerned, the maintenance of ditches in proper condition is often almost as important as the original ditching. It is necessary to keep that portion of the ditch below the flow line free of obstruction, debris and vegetable growth.

Fish Control In many localities, the top minnows (*Gambusia affinis*) are used to control mosquito breeding in lakes, ponds and relatively flat ditches containing several inches or more of quiet, or slowly flowing water. As additional minnows are needed, they are obtained from ponds or hatcheries kept for that purpose.

Larvacides The use of oil and larvacides is often necessary to supplement drainage operations and control mosquito breeding. The method of application of these control agencies is given in detail in reprints mentioned under reference literature.

(6) *What the Engineer Should Know of the Control of Malarial Infected Humans:*

There is always the possibility of those engaged in engineering work suffering a relapse from a previous malarial infection or acquiring this disease on the job. In either case, immediate action should be taken to isolate the sufferer from mosquitoes, and immediate steps taken for his proper medical treatment. Above all, the patient should be housed in a well screened building, from which all mosquitoes have been either driven or killed.

Quinine Quinine is the only specific recognized as efficacious in the cure of malaria. This drug should, when possible, be administered by a physician. Many field engineers and their parties have to live at times beyond the reach of a physician. In such cases the standard treatment for malaria recommended by the National Malaria Committee should be used. See United States Public Health Service reprint No. 672. When entering a malarial locality, the engineer should go prepared to care for those in his party who may become infected.

(7) *What the Engineer Should Know of the Protection of Persons Against Malarial Infection:*

When Anopheles control by means of drainage and larvacides is not practical, we can yet obtain considerable relief by means of effective screening, destroying Anopheles systematically by hand swatting within dwellings, and by the use of quinine.

Screening So far as protection from Anopheles is concerned, a residence is either effectively or poorly screened. Very few screened buildings occupied by construction forces or engineers are effectively screened. More than 75 per cent of screened buildings are not sufficiently well screened to be mosquito proof so far as Anopheles are concerned. All screens subject to abuse should be effectively protected and inspected for defects at definite and frequent intervals, and necessary repairs made at once. Mosquito bars as generally used over beds offer little protection.

In order for screening to be effective the screen should be of sixteen meshes or more to the inch, and fire places, chimney tops, stove pipe flues, and all other sort of openings should be provided with close fitting screens.

Swatting When malaria is seriously prevalent, hand catching or destruction of Anopheles on screens and in bedrooms, can be carried out at little cost with a little effort, and has been proved an effective means of malaria control. Blood gorged Anopheles are much easier to destroy or catch than other mosquitoes. By this method, we kept laborers living on embankments in the swampy jungle of Panama with a lower malaria rate than laborers living in the hill country at Culebra. Boys

can be advantageously used for this work with a proper check and incentive reward for good results.

(8) *Malaria in War Time:*

In our war with Spain (1898) some of the regiments that went to Cuba were of little military value. We established military camps in our southern states and large portions of our troops were potentially sick men, being infected with malaria before leaving for Cuba.

Although American sanitarians^{an} learned how to control malaria during the first period of American occupation of Cuba, 1900-1901, no effective work was done to combat the disease in the United States until twelve years later. This is rather surprising when we realize that malaria costs our country \$100,000,000 annually.

When America entered the world war, the camp sites or cantonments were apparently chosen by persons having no knowledge of the importance of malaria as an item in camp sanitation, and certainly

with no knowledge of malaria control difficulties. It was solely due to the extra effort of a small group of engineers and malaria field workers that we did not have a repetition of the high sick rate that obtained in the Spanish American War. Some of the camps were located with the same lack of care as was followed in the previous war. The mere fact that a camp is on higher ground than the nearby valleys does not make the location a healthy one in the South or in malaria territory. Malaria incidence was apparently not considered as an important factor in cantonment location. One advantageous point gained, however, was the demonstration that by proper care and rapid and efficient work by engineers trained in malaria control, large bodies of men in camp can be kept practically free from malaria at a reasonable cost.

Had the malaria sick rate and malaria death rate been the same in our late war as in the Civil or Spanish-American wars, five thousand enlisted men and officers would have been killed by malaria and there would possibly have been one or two hundred thousand cases of malaria or men temporarily unfit.

By proper malaria drainage and control measures, we lost but thirty-one enlisted men and many of the Southern towns near cantonments found anti-malaria measures a good investment as carried on

during the war. Although the camps are dismantled, the towns are continuing their anti-malaria operations.

(9) *Malaria and Camp Sites:*

Frequently the engineer is called upon to select sites for camps, colonies, villages and towns. In such cases it is necessary for him to decide whether it is more economical and satisfactory to locate at one place and put into effect Anopheles drainage, or to select an alternate location beyond flight range of prolific sources of Anopheles. It is evident that this investigation is in the nature of an engineering problem and not one to be left to the layman or an engineer without knowledge of the important factors that enter the problem. In many instances this subject has not been given proper consideration and the resulting loss or malaria tax has been from five to ten dollars or more per capita per year. In the sanitation of labor camps, the question of drainage for Anopheles control may be of critical importance to the health and efficiency labor status of the settlement. In this connection, Reprint No. 595, United States Public Health Service, can be advantageously studied.

Where drainage is not practical, we may have to depend on screening of laborers' barracks or houses as our line of defense. Screening as generally applied is not of much value in malaria prevention, and intelligent inspection of completed work is essential.

Even in the well organized construction department of the Panama Canal, the screening of buildings was poorly supervised and from 6 to 36 defects were noted in buildings accepted as effectively screened. When numerous openings from one-eighth inch to one inch wide are left in a barrack, it becomes a mosquito trap in which people and malaria infected mosquitoes are kept together.

In the absence of effectively screened quarters in malaria districts, worth while results have been obtained by daily systematic destruction of adult mosquitoes in living quarters. In one Isthmian camp surrounded by a swamp, this method resulted in reducing malaria 90 per cent. Its cost was fifty cents per day.

The day is not far distant when the engineer will be expected to advise communities regarding malaria elimination, and the time has passed when he can afford to change topography in such a manner as to endanger the health of the rural and urban population. In fact, some state health departments have already taken action to pre-

vent such procedure. The engineer who is so unfortunate as not to be actively interested in the health of his working forces or in the ill effects of his construction operations upon the health of neighboring residents may have a difficult time competing with the more progressive engineer who realizes the relative value of applied sanitation.

(10) *Notes for the Field Engineers Note Book:*

Summary of What to Do and What Not to Do.

(a). In areas in the United States where malaria prevails, don't fail to consider standing or sluggish water as a menace to health and its removal or control probably of great importance.

(b). Consider undrained borrow pits as a potential danger that should not be allowed.

(c). Whenever possible, culverts must be so placed as to drain the bottom of all wet lands in the culvert's drainage valley, and not to interfere with future small drainage projects on farm lands, et cetera.

(d). Do not attempt to drain seepage outcrops with "crow-foot" ditches when intercepting ditches are necessary. In making intercepting ditches, the excavated material should be placed on the down hill side of the ditch.

(e). Do not allow contractors or others to dig wide bottom ditches along highways and railroads where narrow bottom ditches can be used, and see that those ditches are dug to proper grade so as to retain a minimum of stagnant water.

(f). Do not fail to use your influence for the proper maintenance of roadway and railroad ditches, particularly near settlements, villages and towns.

(g). Municipal engineers should advise town commissioners to have all roadside pools eliminated, to prevent water standing in roadside ditches in town suburbs, and make every effort to have this necessary work accomplished.

(h). It will be found economical to line the bottom portion of Anopheles producing ditches in town suburbs with concrete, or use drainage pipe, in place of maintaining an open ditch. (In most instances it is necessary to make a concrete cross section sufficiently

large to care for only the normal flow of water remaining after the storm water has gone by.

(i). In establishing labor camps, when possible, locate the camp where Anopheles breeding places within flight range are fewest. Examine all territory within a mile radius of any proposed camp site being considered. Consult with the local medical profession in reference to the presence of malaria, and also the state health department. If the native people want the camp location accepted, they may forget all about the past history of malaria. Inquire at the nearest drug store or grocery store relative to the local sale of chill tonic and be careful how you word your questions. It is advisable to get the information without making your reason for wanting it known.

(j). An engineer who selects the location for a camp is to a certain extent responsible for the future health status or death and sick rate, and should not shirk that responsibility. He can determine in advance whether or not he is going to have a malaria problem to deal with. If so, he should determine how serious it may be and then take necessary precautions accordingly. A most common error is the assumption that a hill top is healthy. This false assumption originated with the idea that malaria was due to fogs or miasmas in the valleys.

(k). Most malaria is transmitted after dark. If the camp is located close to a village or town containing many chronic cases of malaria (walking cases), the men from camp who visit that place after dark will contract malaria if Anopheles are present.

(l). In establishing camps for engineering parties, (if the camp is to remain in one locality much longer than a week) it is advisable to know that you have no malaria carriers among your men who will infect the Anopheles in the vicinity. Such cases should take quinine treatment.

Men who visit families or settlements adjacent to the camps after dark can often be protected by taking prophylactic doses of quinine. Among new arrivals or visitors at the camp may be several cases of malaria.

Gangs of malaria infected foreign laborers working and camping in a suburb of New York City caused a sharp outbreak of malaria there by infecting Anopheles of local origin previously uninfected.

(m). Our engineering schools are now instructing young Americans who will direct important engineering operations later in the countries to the south of us. Students from those countries where malaria is an important sanitary problem are coming to our technical schools. As time goes on, American capital and business interest will play a big part in the development of the natural resources of those countries just as northern capital and business interests are now doing in the southern states. Our engineering schools should not fail to outline the relation of malaria to engineering projects as the future engineer employed in malaria zones cannot afford to be ignorant on this subject. It will frequently happen that the engineer must conquer the malaria problem before it wrecks his project or makes it excessively expensive.

(11) *Reference Literature*; *

Bulletins of the U. S. Public Health Service.

- No. 79—Impounded Water
- No. 88—Malaria Control Studies
- No. 104—Transactions 1st Annual Conference of Sanitary Engineers engaged in Malaria Control.
- No. 115—Transactions 2nd Annual Conference of Sanitary Engineers engaged in Malaria Control.
- No. 125—Transactions 3rd Annual Conference of Sanitary Engineers engaged in Malaria Control.

Reprints From Public Health Reports.

- No. 248—Impounded Waters.
- No. 258—Drainage as an Anti-malaria Measure.
- No. 260—Oiling as an Anti-malaria Measure.
- No. 272—Anopheline Surveys.
- No. 328—Demonstrations in Malaria Control.
- No. 382—Malaria—A Public Health and Economic Problem in the United States.
- No. 396—Flight of Mosquitoes—Studies of distance of Flight of *Anopheles Quadrimaculatus*.
- No. 476—Malaria Control.
- No. 489—The Relation of Railroads of the South to the Problem of Malaria and its Control.
- No. 493—Use of Dynamite in Anti-malaria Drainage Operations.
- No. 511—Mosquito Control about Military Cantonments.
- No. 527—Fishes in Relation to Mosquito Control.

No. 552—The Malaria problem of the South.

No. 595—What Can a Community Afford to Pay to Rid Itself of Malaria.

No. 672—The Standard Treatment of Malaria.

Supplements To U. S. Public Health Service Reports.

No. 32—Field Identification of Malaria Mosquitoes.

No. 18—Malaria—Lessons on its Cause and Prevention—For Use in Schools.

*These publications may be obtained by application to the United States Public Health Service, Washington, D. C.

Malaria Control—A demonstration of its value to Railroads based on the experience of the St. Louis Southwestern Railway Lines.

St. L. S. W. Ry., St. Louis, Mo.

The Prevention of Malaria in the Federated Malay States.

E. P. Dutton Co., N. Y. City, N. Y.

Malaria Control in Panama.

G. P. Putnam's Sons, N. Y. City, N. Y.

